5.—Tertiary Microplankton from the Rottnest Island Bore, Western Australia

By Isabel C. Cookson* and A. Eisenack†

Manuscript received—21st June, 1960

Twelve species of microplankton are recorded from two samples from the Rottnest Island Bore. One new genus *(Rottnestia)*, 4 new species *(Wetzeliella intermedia, Leptodinium maculatum, Rottnestia simplicia, Hystrichosphaeridium paucifurcatum)* and 2 new subspecies *(Deflandrea phosphoritica* subsp. *australis, Hystrichosphaeridium floripes* subsp. *breviradiatum)* are described. The age of the deposit between 1,480 and 1,595 feet is discussed.

Introduction

The occurrence of well-preserved spores, pollen grains and microplankton in core samples from Rottnest Island, Western Australia, was recently recognized by Mr. B. E. Balme and Mr. C. W. Hassell of the University of Western Australia.

We are deeply indebted to Mr. Balme for giving us the opportunity of studying the microplankton content of two samples from 1,480-1,541 feet and 1,575-1,595 feet in the Rottnest Bore, and for stratigraphic information. The necessary preparations for this work were made by one of us (I.C.C.) at the Institute for Geology, Blindern, Oslo, and we wish to thank Professor O. Arbo Hφeg for the facilities he so freely provided.

Most of the types in these two samples have been identified and where necessary described, but a few have had to be omitted on account of rarity, delicacy, or poor preservation.

The exact age of the Rottnest Tertiary sediments is still uncertain. Mr. D. J. Belford in an unpublished report to the Bureau of Mineral Resources, Canberra gives an Upper Eocene age on the basis of Parr's (1937-38) work on the Kings Park Shale of the Perth area. However a suggestion put forward by Crespin in Coleman (1952) that the latter may be of Paleocene age raises the question as to whether the age of the Rottnest deposits, if they correlate with the Kings Park Shale, may not also be Paleocene.

Although this question cannot be resolved by the present contribution, the evidence provided by the microplankton, when taken in conjunction with that of the spores and pollen grains associated with it, indicates that the Rottnest deposits at the depths studied are younger than the Pebble Point Formation of Victoria the age of which is believed to be Lower Tertiary with Paleocene affinities (Baker 1953; Baker and Cookson 1955).

The occasional occurrence in our preparations of a few types of microplankton which, hitherto, have only been found in Upper Cretaceous sediments has led us to consider whether they are natural components of the Rottnest assemblages or contaminants or remanié fossils. At present we are inclined against the idea of their extension into the Eocene and therefore have not recorded them as members of the Rottnest assemblage. A list of these Cretaceous types is given under a separate heading.

* Department of Botany, University of Melbourne, Parkerville N.2, Victoria.
† Institute for Geology, Tübingen, West Germany.

Systematic Descriptions

Dinoflagellates

Family DEFLANDREIDAE

Genus **Deflandrea** Eisenack 1938

Deflandrea phosphoritica Eisenack subsp. **phosphoritica**

(Plate I, Figs. 1, 4)

Deflandrea phosphoritica Eisenack 1938, p. 187, Fig. 6.

Well preserved examples which come within the range of *D. phosphoritica* as described by Eisenack (1938) from the Amber Formation of Samland, East Prussia are relatively numerous in both Rottnest samples. They agree also with specimens identified as *D. phosphoritica* by Manum (1960) from a Lower Tertiary deposit in Spitsbergen in the variable degree of granulation of the outer membrane, the ornamentation of the internal body including the presence of the smooth or less granular dorsal and ventral areas of the internal body and the indication of the longitudinal furrow.

Dimensions.—Length of shell 103-120μ, breadth 82-100μ.

Known Geological Range.—*D. phosphoritica* has been recorded from a Lower Tertiary deposit at Birregurra, Victoria, Australia (Deflandre and Cookson 1955). Its range in Europe is from Paleocene to Middle Oligocene (Alberti 1959, Gerlach 1961).

Deflandrea phosphoritica subsp. **australis** subsp. nov.

(Plate I, Figs. 2, 3; holotype Fig. 2 Nat. Mus. Vict. P20537)

Specimens which differ in certain constant characters from typical examples of *D. phosphoritica* are not uncommon in the Rottnest deposit between 1,480 and 1,541 feet. However, these features do not seem of sufficient importance for specific separation. A new subspecies is therefore proposed for them on the basis of the following differences from the type:— (a) the theca is proportionally longer and narrower; (b) the outer membrane is more closely and coarsely granular especially in the

apical and antapical regions; (c) the horns are more sharply pointed; (d) the apical horn is surmounted by a well-defined solid cylindrical process; (e) the longitudinal furrow is more clearly marked and can be traced downwards from the lower borders of the girdle, the left hand ridge sometimes being straighter than the right hand one.

Dimensions.—Type—length 146μ, breadth 94μ, internal body 71 x 80μ. Range—length 105-146μ, breadth 83-102μ.

Genus **Wetzeliella** Eisenack 1938

Wetzeliella lineidentata Deflandre and Cookson
(Plate I, Fig. 7)

Wetzeliella lineidentata Deflandre and Cookson, 1955, p. 253, Plate V, Fig. 5.

This species, hitherto known only by one imperfect specimen from a Lower Tertiary deposit near Denmark, Western Australia, occurs in the Rottnest deposits between 1,480 and 1,541 feet and 1,575 and 1,595 feet.

The new examples show that, as Deflandre and Cookson (1955) suggested, the epitheca is triangular in shape with straight or slightly concave sides and that the apical horn is not strongly developed. The shells are approximately as broad as long and usually show indications of a girdle as low ledges, especially in the region of the lateral horns, or as two rows of blunt spines. In a few specimens the marginal denticulation agrees with that of the type in others (Plate I, Fig. 7), the teeth are more strongly developed. Distinct fields, which are delimited by rather prominent teeth, are evident in most specimens. but the tabulation is not a true one.

Dimensions.—Length 148-152μ, breadth 113-152μ.

Wetzeliella intermedia sp. nov.
(Plate I, Figs. 5, 6; holotype Fig. 5 Nat. Mus. Vict. P20538)

Description.—Shell flat, usually somewhat longer than broad, rounded-rhombic in outline with slightly convex to nearly straight sides and a broadly rounded apex with one or two centrally placed teeth. The lateral horns are represented by slight, broadly-rounded or indented expansions of the outer membrane; a single short pointed horn is developed to one side of the antapex. A circular girdle which crosses the shell in its broadest region is indicated by low ledges or folds especially at the lateral margins or by two rows of short teeth. The margins of the shell are smooth or slightly wavy or toothed the dorsal and ventral surfaces are either smooth or sparingly dotted, the dots sometimes outlining fields comparable with those of *W. lineidentata*. The internal body is large, flat, and oval in outline its wall is thin and in optical section is seen to be composed of small, closely arranged rods. A large squarish pylome is situated in the epitheca.

Dimensions.—Type—length 125μ, breadth 122μ; internal body 100 x 100μ. Range—length 111-143μ, breadth 97-130μ.

Comments.—*Wetziella intermedia* as its name suggests, seems to be a form intermediate between *W. lineidentata* and *W. glabra* Cookson. The slightly denticulate margins and surface thickenings, sometimes linearly arranged so as to enclose fields, indicate a certain relationship with *W. lineidentata*, on the other hand the practically smooth margin and surface of other examples suggests an affinity with *W. glabra*. In the oval shape of the shell and the reduced form of the horns *W. intermedia* is distinct from *W. lineidentata* and *W. glabra*.

W. intermedia agrees with *W. rhomboidea* Alberti (1961) in certain features, but the latter species has no indication of spines.

Family GONYAULACIDAE
Genus **Leptodinium** Klement 1960

Leptodinium maculatum sp. nov.
(Plate II, Figs. 5, 6; holotype Nat. Mus. Vict. P20539)

Description.—Shell oval to nearly spherical, without a horn. Girdle equatorial, strongly helicoid and rather broad with low borders. Longitudinal furrow broad, elongate-rectangular, bounded antapically by a large plate. Plates strongly outlined, bordered by low, thin, hyaline ledges. Surface of the plates distinctly dotted. Pylome formed by removal of plate 3''. Tabulation 4', 6'', 5''', 1 p, 1''''.

Dimensions.—Type 52μ long, 50μ broad. Range. Length 52-64μ, breadth 48-60μ.

Comments.—*L. maculatum* is close to the Upper Oligocene species *L. membranigerum* Gerlach 1961 from north-western Germany. However the latter can be distinguished from the Rottnest species by its more elongated egg-shaped form, the higher ledges and the finely granular surface of the plates.

Family incerta
Genus **Rottnestia** gen. nov.

Description.—The shells consist, like those of a number of fossil dinoflagellates, of an internal body and a thin outer membrane. The

PLATE I*

Fig. 1.—*Deflandrea phosphoritica* Eisenack, × *ca.* 430, P 20554.

Figs. 2, 3.—*Deflandrea phosphoritica* subsp. *australis*, subsp. nov., Fig. 2, type × *ca.* 430, P 20537; Fig. 3, another example showing longitudinal furrow × *ca.* 330, P 20553.

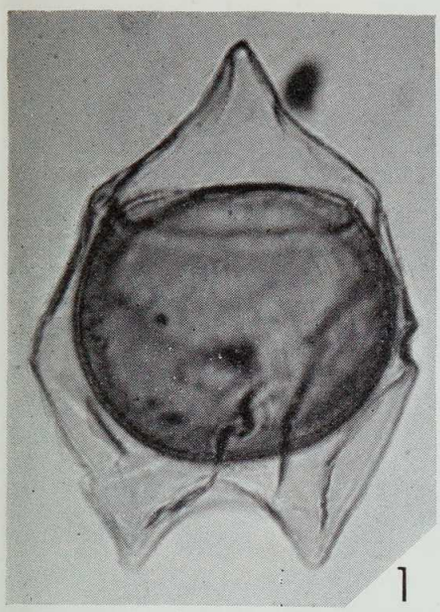
Fig. 4.—*Deflandrea phosphoritica* Eis. Ventral surface of internal body showing "smooth" area × *ca.* 500, P 20552.

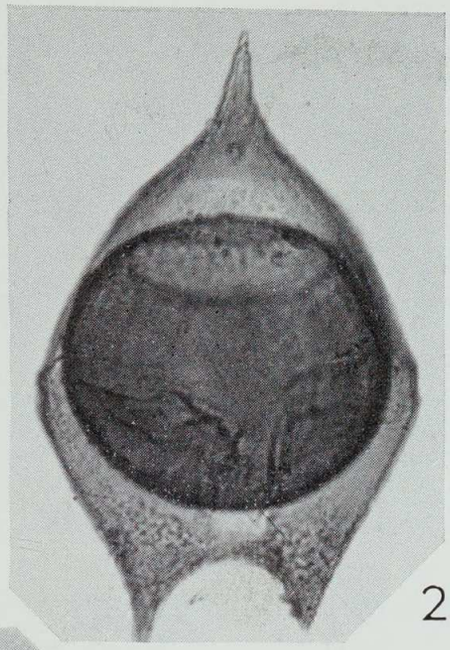
Figs. 5, 6.—*Wetzeliella intermedia* sp. nov.; Fig 5, type × 450, P 20538; Fig. 6 a more highly ornamented specimen × *ca.* 400, P 20553.

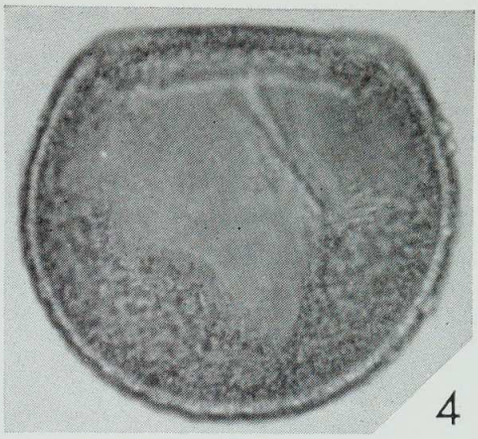
Fig. 7.—*Wetzeliella lineidentata* Deflandre and Cookson × 450, P 20550.

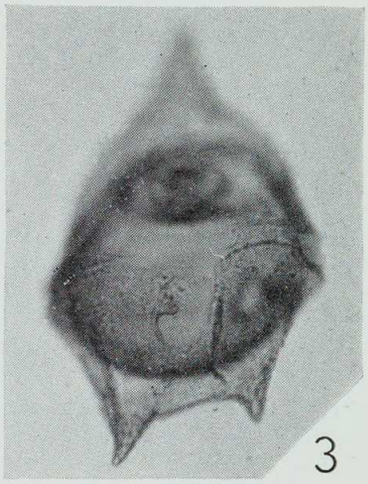
Figs. 8-10.—*Rottnestia borussica* (Eisenack). Fig. 8 one of the original specimens from the Amber Formation, East Prussia, × *ca.* 400. Figs. 9, 10 highly ornamented examples from Rottnest Bore × 380, P 20541, P 20551.

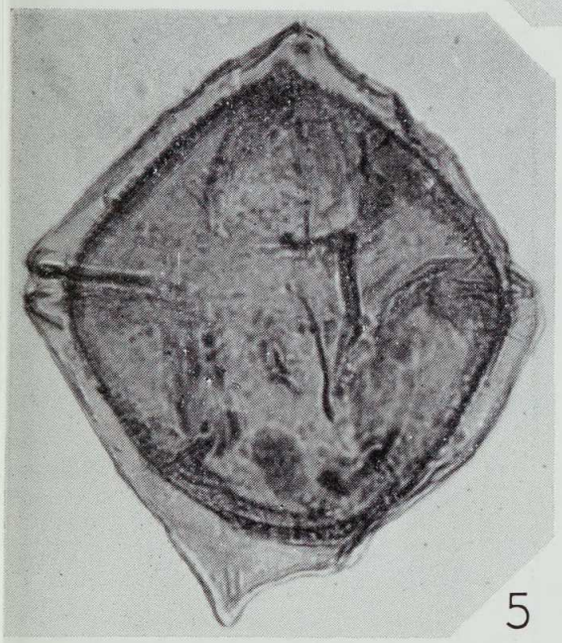
* The photographs in Plates I and II were taken by A. Eisenack. All are of specimens from the Rottnest Bore between 1,480 and 1,595 feet except Plate I, Fig. 8 which is from the Amber Formation of East Prussia. Registered numbers in the palaeontological collection of the National Museum of Victoria are given.

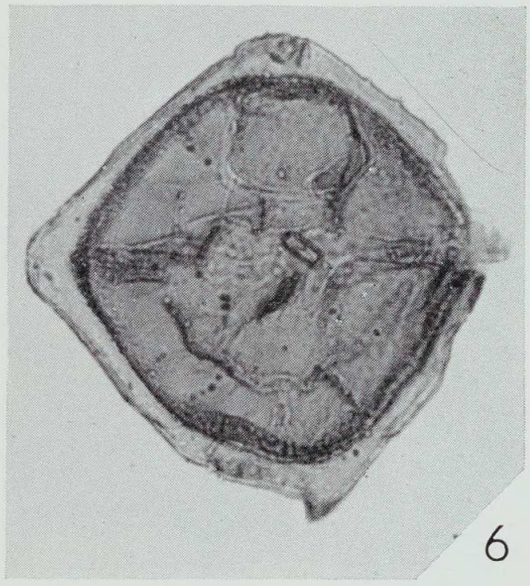


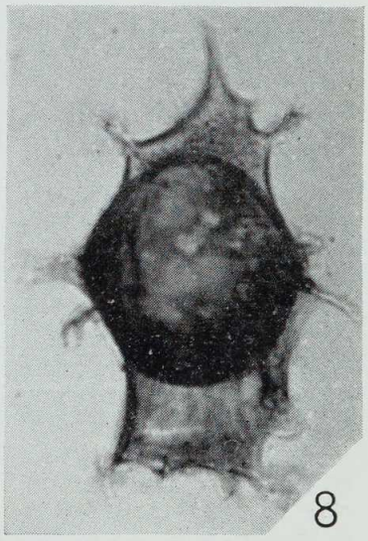


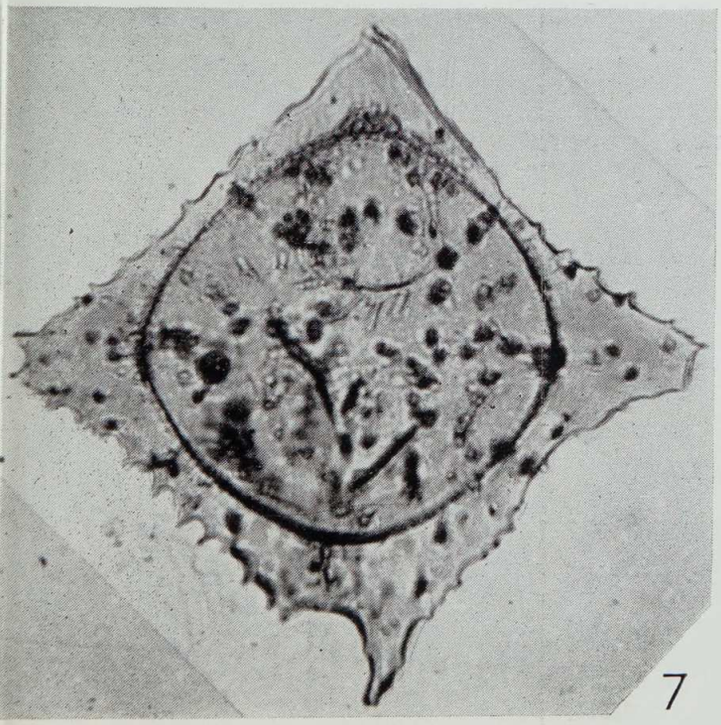


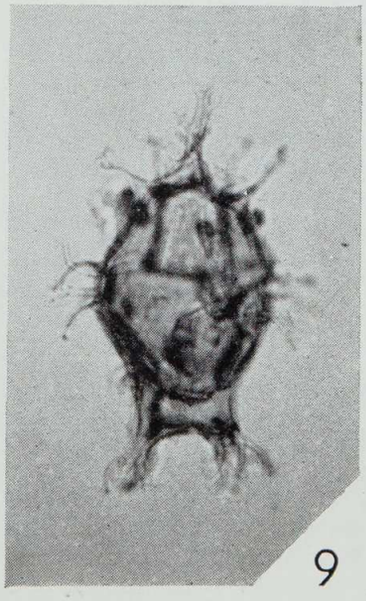












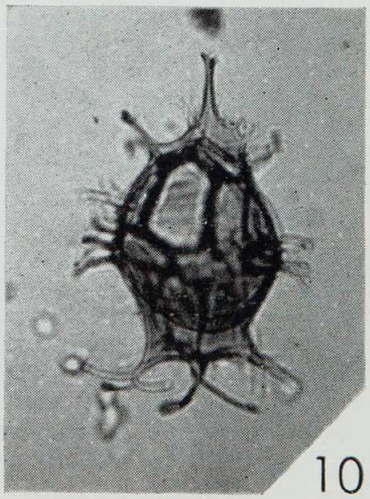


PLATE I

internal body is clearly defined and oval in shape. The outer membrane is in contact with the internal body in the central region but extends beyond it both apically and antapically. The apical expansion is surmounted by a median conical or cylindrical horn; the antapical expansion is squarish in shape with sharp or rounded angles. The shell is crossed by a median helicoid girdle and a relatively broad longitudinal furrow runs obliquely across the ventral surface. The surface of the outer membrane is divided into pre- and post-equatorial fields the limits of which run into the edges supporting the apical and antapical expansions. Forked appendages may or may not be developed at the corners of the fields. A large elongate-trapezoid pylome develops on the dorsal side of the epitheca in both the internal body and outer membrane.

Type species *Hystrichosphaera borussica* Eisenack.

Rottnestia borussica (Eisenack)

(Figs. 1a, 1b, 1c, 1d; Plate I, Figs. 8-10; Plate II, Figs. 1, 2)

Hystrichosphaera borussica Eisenack 1954, p. 62, Plate IX, Figs. 5-7.

Hystrichosphaera borussica Eisenack in Deflandre and Cookson, 1955, p. 263, Plate V, Figs. 9, 10.

Rottnestia borussica was established in 1954 on 3 specimens two of which, including the type, had lost their apical expansions. The better preserved Rottnest examples from between 1,480 and 1,595 feet, which are obviously specifically identical with the German ones have thrown fresh light on this form both as regards the morphology and the affinity of the species. A new description based on both the German and Australian specimens is therefore given here.

Description.—Shell considerably longer than broad with a prominent internal body which is in contact with the outer membrane except at the poles. Both apical and antapical expansions of the outer membrane are usually strongly developed. The apical expansion narrows distally; its margins are rather deeply embayed and in perfect specimens it bears a well defined median cylindrical horn. The antapical expansion is broader, angular in section and is supported by 5 or 6 (usually 6) ledges. The girdle is clearly defined and crossed on the dorsal surface by vertical ledges which mark out transversely elongate-rhombic areas. The longitudinal furrow runs obliquely across the ventral surface from the base of the apical expansion almost to the upper limit of the antapex. Both the epitheca and hypotheca have more or less clearly defined fields which, usually, are longer than broad; their boundaries run to the outer limits of the shell.

In the specimens from East Prussia and some of those from the Rottnest Bore forked appendages are developed at the corners of the fields. A few of the Rottnest examples have no appendages. A large pylome extends from the girdle almost to the upper limit of the internal body, the opening in the outer membrane coinciding with that of the internal body.

Comments.—As was mentioned by Eisenack in 1954 the three forms of *Hystrichosphaera* described by Deflandre 1937, i.e. *Hystrichosphaera speciosa, H. ovum* and *H. wetzeli* are probably all related to *Rottnestia borussica.*

In his description of *H. speciosa* Deflandre mentions "plaques cingulaires en helice levogyre" but since the figure given is of the dorsal surface it is not possible to judge whether a longitudinal furrow or longitudinally arranged fields were present. In *H. ovum* the apical and antapical expansions have the same construction as those of *R. borussica* but, apart from the development of a girdle, the figures give little information regarding the presence and arrangement of fields. In *H. wetzeli,* on the other hand, the ledges are developed as rather high membranes and there is a clearly marked girdle formed by elongate-rhombic fields as in *R. borussica.* The figured specimen shows the dorsal surface, but Deflandre, himself, speaks of a "direction des appendices qui soutienment les voiles de la partie postérieure, direction qui est parallèle au grand axe de la logette et non radiante". It seems possible therefore that this longitudinal arrangement of the fields is also present on the "posterior" surface as in *R. borussica.*

However, only a further investigation of the three Cretaceous species will determine their relationship to *Rottnestia.*

Rottnestia simplicia sp. nov.

(Figs. 1e, 1f; Plate II, Figs. 3, 4; holotype Nat. Mus. Vict. P20541)

Occurrence.—Rottnest Bore at 1,575-1,595 feet.

Description.—Shell without appendages. Apical and antapical expansions of the same construction as those of *R. borussica* but less strongly developed, apical horn well marked. Longitudinal furrow distinct, broadening towards the antapex. Girdle, tabulation and pylome similar to those of *R. borussica.* The internal body is elongate-oval in outline.

Dimensions.—Type—Length 83μ, breadth 56μ, internal body 60 x 38μ.

PLATE II

Figs. 1, 2.—*Rottnestia borussica* (Eisenack). Ventral and dorsal surfaces of a specimen without appendages × *ca.* 500, P 2054Y.9.

Figs. 3, 4.—*Rottnestia simplicia* sp. nov. Ventral and dorsal surfaces of type × *ca.* 500, P 20541.

Figs. 5, 6.—*Leptodinium maculatum* sp. nov. Ventral and dorsal surfaces of type × *ca.* 700, P 20539.

Figs. 7, 8.—*Hystrichosphaeridium floripes* Deflandre and Cookson, Fig. 7 × *ca.* 390, Fig. 8 × *ca.* 450.

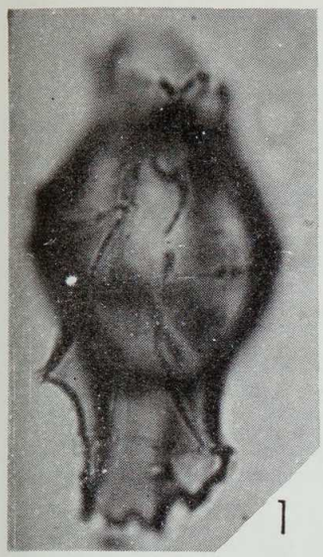
Fig. 9.—*Hystrichosphaeridium colligerum* Deflandre and Cookson × *ca.* 500, P 20540.

Figs. 10, 11.—*Hystrichosphaeridium floripes* subsp. *breviradiatum* subsp. nov. at two foci × *ca.* 400, P 20542.

Fig. 12.—*Cannosphaeropsis* cf. *caulleryi* Deflandre × *ca.* 500, P 21304.

Figs. 13, 14.—*Thalissophora velata* (Deflandre and Cookson). Two para-types × *ca.* 230, P 21302, P 20303.

Fig. 15.—*Hystrichosphaeridium paucifurcatum* sp. nov., type × *ca.* 240, P 20543.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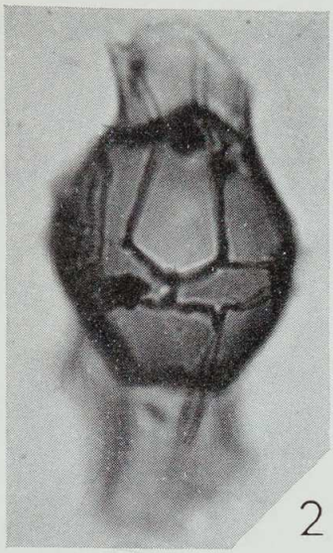
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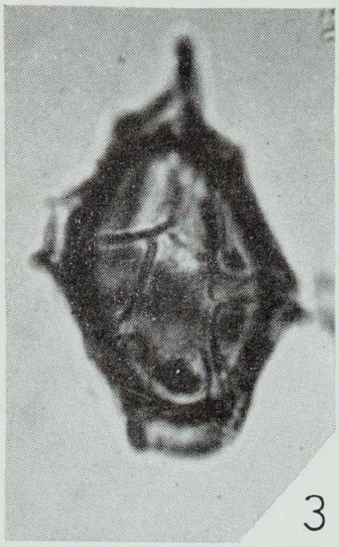
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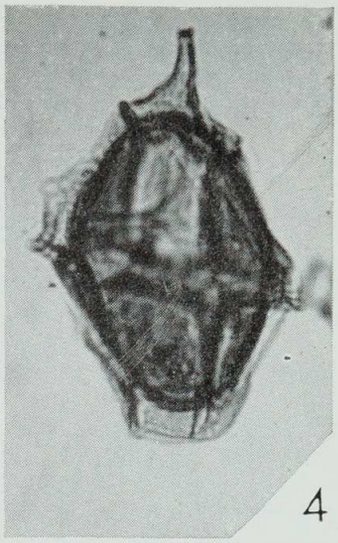
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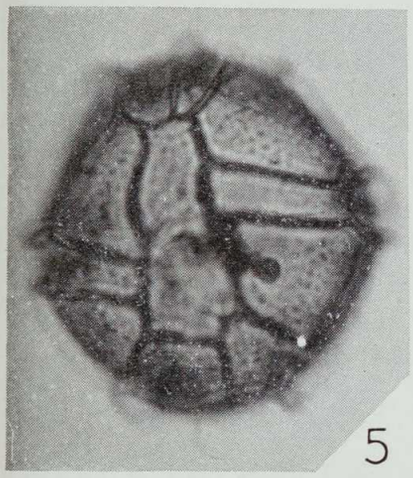
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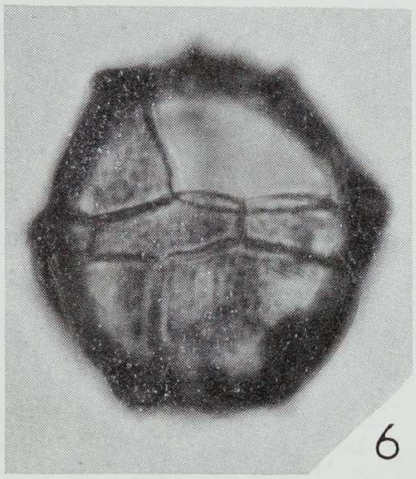
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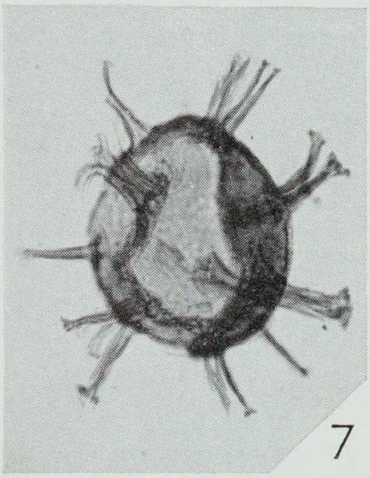
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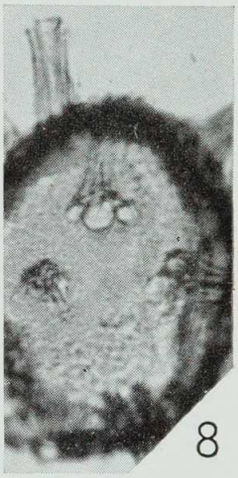
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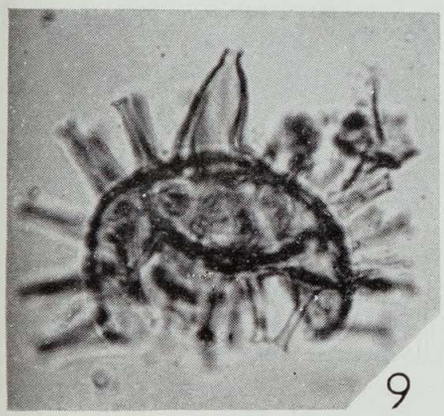
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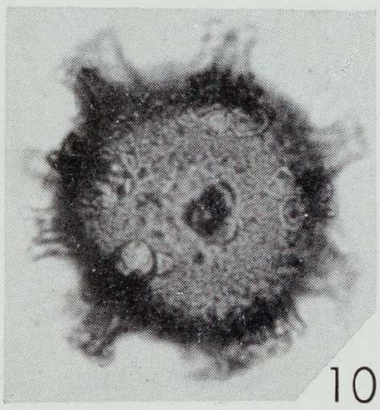
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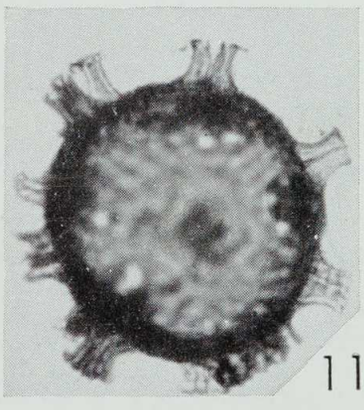
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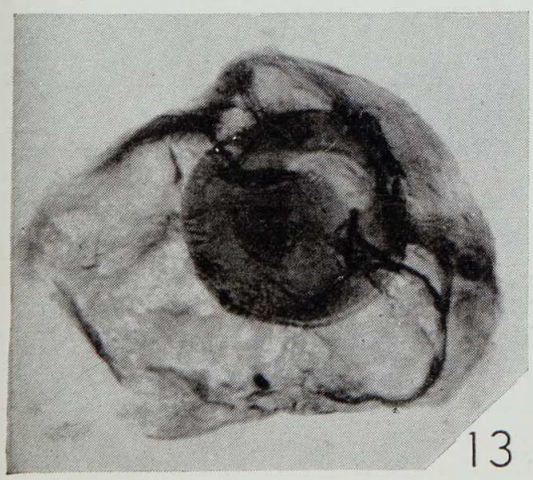
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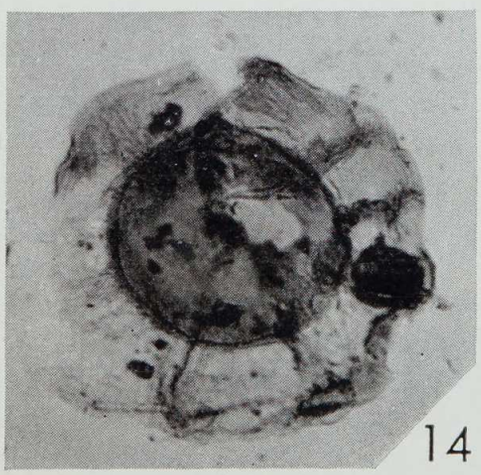
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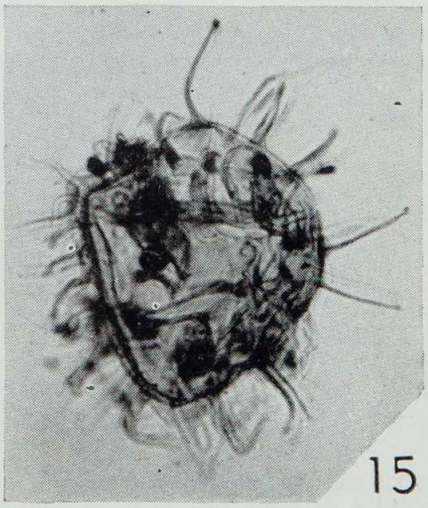
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PLATE II

Comments.—This species is based on a single but well preserved specimen. In it the dinoflagellate characters are even more strongly marked than in *R. borussica*.

Hystrichospheres

Family HYSTRICHOSPHAERIDAE

Genus **Hystrichosphaeridium** Deflandre 1936

Hystrichosphaeridium floripes Deflandre and Cookson

(Plate II, Figs. 7, 8)

Hystrichosphaeridium floripes Deflandre and Cookson 1955, p. 176, Plate VII, Figs. 1, 2, 7.

H. floripes is the most numerous individual type in the Rottnest Bore sample between 1,480 and 1,541 feet. It appears to be absent from the sample between 1,575 and 1,595 feet. The Rottnest examples agree in all respects with those occurring in the Lower Tertiary "Coffee Rock" from the Western Australian Government Railway Department's Bore 9 between 18 and 27 feet near Denmark, Western Australia (Deflandre and Cookson 1955).

Hystrichosphaeridium floripes subsp. **breviradiatum** subsp. nov.

(Plate II, Figs. 10, 11; holotype Nat. Mus. Vict. P20542)

Description.—Similar to *H. floripes* but with considerably shorter and proportionally broader appendages.

Dimensions.—Holotype—Overall diameter 86μ, diameter of shell 66μ; appendages 10-15μ.

Comments.—This subspecies occurs in small numbers in the Rottnest sample between 1,480 and 1,541 feet.

Hystrichosphaeridium colligerum Deflandre and Cookson

(Plate II, Fig. 9)

Hystrichosphaeridium colligerum Deflandre and Cookson 1955, p. 273, Plate VII, Fig. 3.

The imperfectly preserved figured specimen is the only undoubted example of this species recovered from the Rottnest deposits. However the presence of a large cylindrical appendage in association with numerous smaller tubular processes leaves no doubt as to its affinity. It was recovered from the sample between 1,480 and 1,541 feet.

H. colligerum was described from specimens isolated from the Princetown Member of the Dilwyn Clay, Victoria, the age of which is believed to be Lower Eocene (Baker 1953).

Hystrichosphaeridium paucifurcatum sp. nov.

(Plate II, Fig. 15; holotype Nat. Mus. Vict. P20543)

Occurrence.—In the Rottnest Bore between 1,480 and 1,595 feet.

Description.—Shell spherical to slightly oval, thin-walled, faintly granular, closely covered with long, slender, solid appendages which taper gradually towards their slightly bifurcate apices. The fine fibrils of which the appendages are composed splay out slightly on the surface of the shell.

Dimensions.—Holotype—Diameter of shell *ca.* 112μ length of appendages *ca.* 42μ long.

Genus **Cannosphaeropsis** O. Wetzel 1933

Cannosphaeropsis cf. **caulleryi** (Deflandre)

(Plate II, Fig. 12)

Hystrichosphaeridium caulleryi Deflandre 1938, Trav. Sta. Zool. Wimereux, 13: 189, Plate XI, Figs. 2, 3.

Cannosphaeropsis caulleryi (Deflandre); Deflandre 1947, C.R. Acad. Sci. Paris, 224: 1576.

Cannosphaeropsis cf. caulleryi (Deflandre); Cookson 1953, Mem. Nat. Mus. Melb. 18: 117, Plate II, Figs. 35-40.

Cannosphaeropsis caulleryi (Deflandre); Deflandre and Cookson 1955, Aust. J. Mar. Freshw. Res., 6: 283, Plate VII, Fig. 8.

A few imperfect shells which appear to have similar characters to those of the Australian specimens referred by Deflandre and Cookson (1955) to the Jurassic species *C. caulleryi* have been isolated from the Rottnest samples between 1480 and 1541 feet.

The specimens identified by Deflandre and Cookson were recorded from the following Victorian deposits: Pebble Point Formation (Paleocene to Lower Eocene); Birregurra Bore at 842-843 feet (? Lower Eocene); Princetown Member of Dilwyn Clay (Lower Eocene); Anglesea Siltstone (? Middle Eocene).

Incertae sedis

Genus **Thalassiphora** Eisenack and Gocht 1960

Thalassiphora velata (Deflandre and Cookson)

(Plate II, Figs. 13, 14; holotype Nat. Mus. Vict. P16246)

Pterocystidiopsis velata Deflandre and Cookson, 1955, p. 291, Plate VIII, Fig. 8.

A careful study of the type specimen of *Pterocystidiopsis velata* from near Denmark, Western Australia, in the light of the better preserved specimens of a similar nature from the Rottnest samples has shown that the body is not enclosed by the delicate wing-like membrane to which it is attached. The type together with the Rottnest specimens, cannot, therefore, be included in the genus *Pterocystidiopsis* Deflandre since the body of the type of that genus lies completely within the outer membrane. On the other hand both the Denmark and Rottnest samples fall readily into the new genus *Thalassiphora* Eisenack and Gocht.

Description.—The shells of *T. velata* consist of a spherical to oval body and a thin and relatively wide saucer-shaped wing-like membrane. The body has a rather firm, faintly granular wall and a distinct pylome is developed. The body is attached to the central region of the wing by numerous root-like strands from which fibrils separate out in a fan-shaped manner.

Dimensions.—Body *ca.* 95-105μ, diameter of wing *ca.* 160-240μ.

Comments.—*T. velata* is close in all respects to *T. pelagica* (Eisenack) from the Amber Formation of Eastern Germany the only significant difference being the small tail-like projection at the periphery of the wing of the latter.

Eisenack and Gocht (1960) have recently removed *T. pelagica* from the genus *Pterospermopsis* W. Wetzel and established the genus *Thalassiphora* for Eisenack's *Pterospermopsis pelagica*.

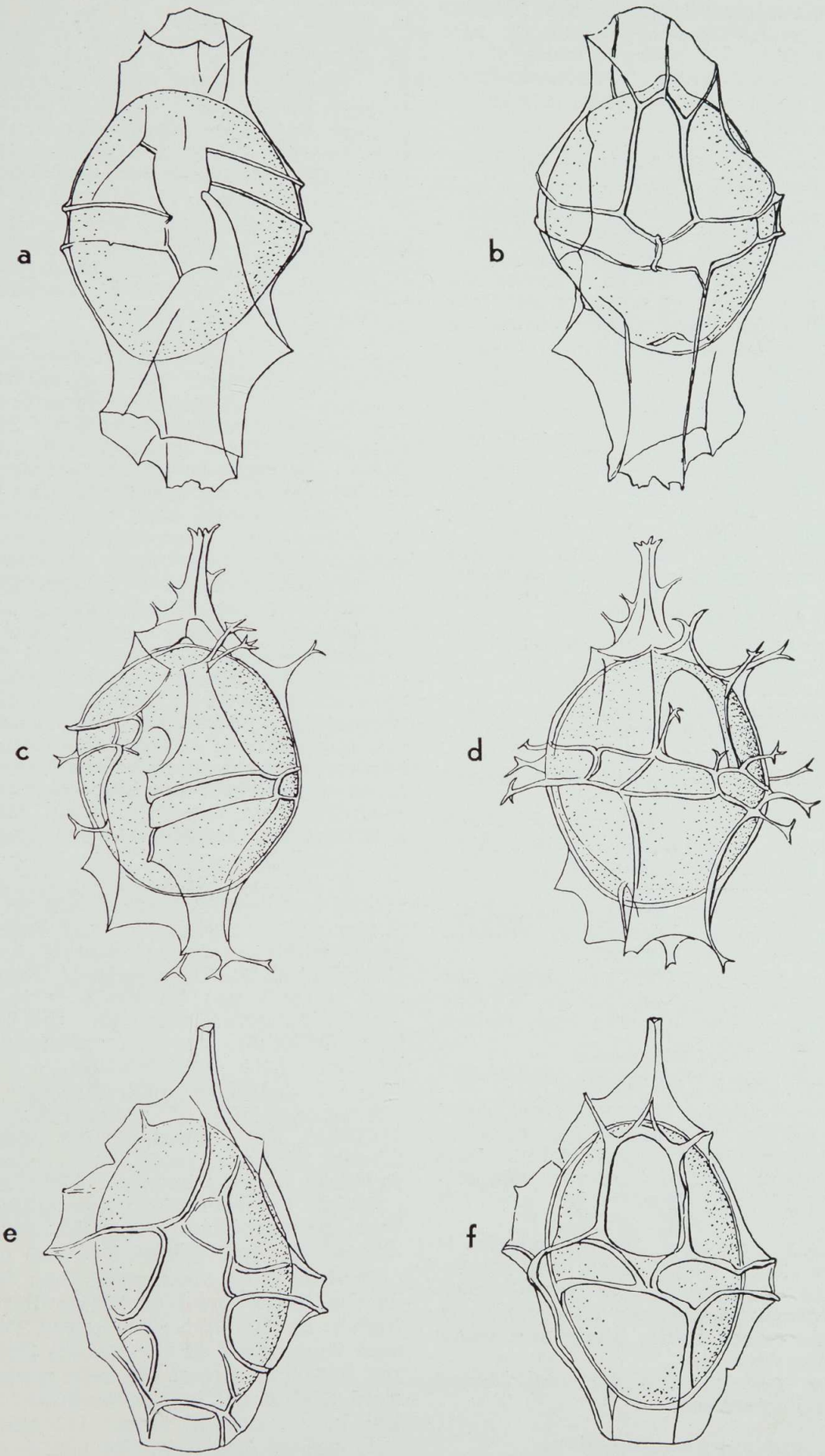

Fig. 1.—(a) and (b) *Rottnestia borussica* (Eisenack), ventral and dorsal surfaces of a specimen without appendages, × *ca.* 640 (c) and (d) *Rottnestia borussica,* ventral and dorsal surfaces of a specimen with an apical horn and a few appendages, × *ca.* 640 (e) and (f) *Rottnestia simplicia* sp. nov., ventral and dorsal surfaces of the same specimen, × *ca.* 640.

Genus **Crassosphaera** Cookson and Manum 1960

Crassosphaera stellulata Cookson and Manum

Crassosphaera stellulata Cookson and Manum. Nytt Mag. Bot. Oslo, 8: 5-9.

This species occurs in the Rottnest Bore deposits between 1480 and 1595 feet. It has not been found elsewhere.

"Mesozoic" Types from the Rottnest Deposits

As already mentioned a few Mesozoic types have been observed in the Rottnest residues. All have been recorded from Western Australian deposits particularly from the Greensand of the Gingin area and the Osborne Formation of the Perth Basin. The significance of their occurrence cannot be determined without a thorough investigation of the deeper portions of the bore.

Microplankton

Gonyaulax hyalodermopsis Cookson and Eisenack from the South Perth Formation, Western Australia, Attadale Bore at 809 feet, Grierson Member of Birdrong Formation, Western Australia, Meadow Station Bore No. 9.

Deflandrea echinoidea Cookson and Eisenack from the Toolonga Calcilutite, Western Australia; Wapet's Seismic Shot Hole B 1; north of Gingin, Western Australia, at 160 feet.

Nelsoniella aceras Cookson and Eisenack from the Toolonga Calcilutite, Western Australia, (Senonian), Wapet's Seismic Shot Hole B 1, at 160 feet (Turonian to Middle Senonian); Nelson Bore at 5,304 feet, Victoria (Upper Cretaceous).

Nelsoniella semireticulata Cookson and Eisenack from Wapet's Seismic Shot Hole B1, at 120, 160 feet.

Nelsoniella tuberculata Cookson and Eisenack from the Toolonga Calcilutite, Western Australia, Wapet's Seismic Shot Hole B 1, at 120, 160 feet.

Diconodinium dispersum Cookson and Eisenack from the Osborne Formation, Western Australia, Subiaco Bore at 358 feet.

Odontochitina porifera Cookson from the Toolonga Calcilutite, Western Australia, Wapet's Seismic Shot Hole B 1 at 160, 170 feet; Nelson Bore, Victoria, at 6,233 feet.

Spores and Pollen Grains

Hoegisporis lenticulifera Cookson from Australian Upper Aptian to Cenomanian deposits including the Osborne Formation, Western Australia, Subiaco Bore at 358 feet and Wapet's Seismic Shot Hole B 1 between 190 and 220 feet.

Zonalapollenites dampieri Balme which is plentiful in the South Perth Shale and Upper Jurassic deposits in Australia and New Guinea.

Classopollis torosus Reissenger (seen by B. E. Balme) from the South Perth Shale and other Lower Cretaceous deposits.

Only one or two of the abovementioned types have been observed.

Stratigraphical Considerations

Evidence from Microplankton

Apart from indicating a Lower Tertiary age the small number of microplankton types present gives no precise indication of the age of the Rottnest samples.

One of the commonest species *Deflandrea phosphoritica* has a comparatively wide range in the Lower Tertiary of Europe, recent records having extended its range from Paleocene to Middle Oligocene. In Victoria *D. phosphoritica* has been recorded from a deposit in the Birregurra Bore at a depth of 876-877 feet. The age of this is certainly younger than that of the Pebble Point Formation (Paleocene to Lower Eocene, Baker 1953) and has been given as ? Lower Eocene (Cookson 1954).

In Europe the genus *Wetzeliella* has its main development in the Lower Tertiary with species ranging from Upper Paleocene to Upper Oligocene (Alberti 1961). *W. lineidentata* which occurs in the Rottnest deposit between 1,480 and 1,595 feet has been previously recorded from a deposit near Denmark, Western Australia. On its pollen content, the age of this is Lower Tertiary and definitely younger than that of the Pebble Point Formation (Paleocene to Lower Eocene). The deposit at Noarlunga, South Australia, in which W. *glabra* occurs, is of approximately the same age. This species is closely allied to the Rottnest species *W. intermedia*. *Leptodinium maculatum* of the Rottnest Bore is most closely related to *L. membranigerum* from Upper Oligocene beds in north-western Germany.

The only locality, apart from the Rottnest deposit between 1,480 and 1,595 feet in which undoubted examples of *Rottnestia borussica* have been found is the Upper Eocene Amber Formation of Samland, East Prussia. *Thalassiphora pelagica* also from the Amber Formation agrees closely with *T. velata* from the Rottnest Bore. *Hystrichosphaeridium colligerum* has been recorded from the Princetown Member of the Dilwyn Clay, Victoria (Lower Eocene).

Evidence from Pollen Grains

The pollen content of the Rottnest deposits as a whole is being studied by Mr. D. M. Churchill at the University of Western Australia and so will not be dealt with here in any detail. However, when the age of a deposit is in doubt as many microfossils as possible should be taken into consideration.

Three distinctive pollen species, all of which are components of "Microflora C" (Cookson 1954) in the Victorian and South Australian Lower Tertiary have been observed in the Rottnest deposit between 1,480 and 1,541 feet namely: *Proteacidites pachypolus* Cookson and Pike, *Beaupreidites elegansiformis* Cookson and *Anacolosidites acutulus* Cookson and Pike.

Proteacidites pachypolus has been advanced as the index fossil of *"Microflora C"* for beds higher in the Victorian Lower Tertiary succession than those of the Pebble Point Formation, but the exact age of the beds containing "Microflora C" has not been determined. *P. pachypolus* has been recorded from: (1) the carbonaceous silts one at Anglesea, the age of which is given by Raggatt and Crespin (1952 p. 146) as ? Middle Eocene: (2) the basal clays of the Castle Cove section which may be Upper Eocene or older (fide Dr. O. P. Singleton): (3) the beds in the Nelson Bore at 992 feet which have been

dated as Lower Eocene (Baker and Cookson 1955) and (4) the Birregurra bore between 760 feet and 960 feet.

Anacolosidites acutulus, also a component of "Microflora C" has been recorded from the Birregurra Bore between 760 and 900 feet, and the Anglesea Siltstone. *Beaupreidites elegansiformis* occurs in an Eocene deposit at Alberton West (Cookson and Dettmann 1959) and in the Yallourn Brown Coal of ? Oligocene age.

Conclusions

Although the evidence from these two sets of microfossils is inconclusive, it shows that the Rottnest deposits are Eocene and clearly younger than the Paleocene to Lower Eocene Pebble Point Formation of Victoria. Further than this one cannot go until the beds in which "Microflora C" occurs are more reliably dated by other means. The Upper Eocene age suggested by Belford for the Rottnest Bore deposits on the basis of foraminifera is not incompatible with their pollen and microplankton content, but it is equally possible that they may have been somewhat older than this.

Correlation with the Carbonaceous Deposits near Denmark, Western Australia

In 1955 a small microplankton assemblage was recorded by Deflandre and Cookson from bore samples of a carbonaceous sandy deposit situated near the Hay-Denmark railway deviation, 354 miles from Perth, Western Australia. Associated with this assemblage were pollen grains some of which could be identified with types, including *Proteacidites pachypolus*, occurring in the "Microflora C" of south-eastern Australia.

The microplankton assemblages of the Denmark and Rottnest deposits, although not identical, are sufficiently similar, as will be seen from Table I, to permit a close correlation between them.

TABLE I

	Rottnest Bore	Denmark Deposit
Deflandrea phosphoritica	+	—
Wetzeliella lineidentata	+	+
Wetzeliella intermedia	+	—
Rottnestia borussica	+	?
Hystrichosphaeridium floripes	+	+
Thalassiphora velata	+	+
Epicephalopyxis indentata	—	+

The occurrence in both deposits of the two distinctive species *Hystrichosphaeridium floripes* and *Thalassiphora velata* neither of which has, as yet, been found elsewhere is significant. All indications are that the Rottnest and Denmark deposits are of approximately the same age.

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